



National Aeronautics and  
Space Administration

# NASA

## Facilities Engineering Report

March 2001



National Aeronautics and  
Space Administration

**Headquarters**

Washington, DC 2046-0001



23 March 2001

I am pleased to present this Report describing NASA's Facilities Engineering Programs. Accomplishments noted reflect the commitment of our outstanding civilian and contractor professionals. NASA's facilities engineers are committed to excellence. The facilities engineering team continuously strives to improve the products, processes, and services we provide to our customers.

NASA's missions are many, varied, and complex. NASA facilities engineers provide continuous support to these operational missions. This support requires a broad range of one-of-a-kind facilities, and a cadre of dedicated civil service and contractor facilities professionals. Together, these physical and human assets help ensure the safety and success of NASA's human space flight, earth sciences, biological, and aerospace programs.

This report provides an overview of NASA's facilities and the people who plan, design, construct, operate, and maintain them. Recent accomplishments are chronicled, and future challenges and opportunities are explored. As you read this, remember that "our people" are a key element in improving and sustaining the capability to provide mission support.

During the last decade, NASA has pushed the envelope in Federal facilities management. Through perseverance and hard work, our facilities engineers helped develop best practices in pre-project planning, design, and construction methods; partnering; Reliability-Centered Maintenance; and facilities maintenance and operations contracting. As we embark into the 21st century, we expect these and other initiatives to bear fruit, including sustainable design, applications of technology in the design and construction of facilities practices, building commissioning, and geo-spatial maintenance.

The facilities challenges facing us provide many opportunities to apply dynamic leadership in concert with technology. By 2005, 75 percent of NASA's more than 40 million square feet of facilities will be at least 35 years old. We must maintain and reshape this infrastructure to support current and future missions. This will require substantially increased investment over those in recent years, and an aggressive strategy to leverage existing assets using innovative financing approaches. Projects like the NASA Research Park at Ames Research Center, which use non-traditional sources of funding to develop cutting-edge research facilities, must become commonplace within the Agency. Creativity and innovation are essential to meeting our future research and operational mandates.

I am confident that through the hard work, devotion, and extraordinary talent of NASA's Facilities Engineering Team we will enter the 21st century continuing to produce the critical support essential for NASA's ongoing success.

A handwritten signature in black ink, reading "William W. Brubaker".

William W. Brubaker, P.E.  
Director of Facilities Engineering

## NASA Facilities Engineering— An Overview

NASA's facilities managers ensure owned and operated facilities enhance and support Strategic Enterprise and Center missions. Facilities engineering organizations provide: facilities planning; real estate development; requirements assessments; design and construction services; operations and maintenance services; resource planning; and disposal services. Facilities engineers work closely with safety, environmental, and other support organizations to ensure NASA provides safe, efficient, and environmentally friendly workplaces. Professionals throughout the Agency work closely with the NASA Facilities Engineering Division, Code JX, to solve common problems and share best practices for improving support to Agency missions. Through the combined efforts of dedicated facilities professionals, NASA operations will continue to receive state of the art support for our constantly changing missions.

*"NASA is an investment  
in America's future. As explorers,  
pioneers, and innovators, we  
boldly expand frontiers in air and  
space to inspire and serve  
America and benefit the quality of  
life on Earth."*

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# introduction

## Introduction

NASA owns more than 5,000 facilities with 42 million square feet and a current replacement value of \$20 billion. NASA Centers occupy more than 100,000 acres on strategically important and environmentally sensitive Federal land. This report reviews current capabilities, recent accomplishments, and future challenges facing NASA facilities managers. Past accomplishments and future challenges highlighted in this report clearly demonstrate NASA's leadership among federal facilities management practices.

NASA's evolving mission requires changes in past and current facilities management practices. New or modified facilities are needed to keep pace with changing requirements. Maintaining facilities in accordance with the Federal facilities management system presents significant challenges for NASA. Some of these challenges include maintaining facilities whose average age is increasing; turning the table on an aging facilities engineering workforce; and programming the projected level of funding for facilities operations, maintenance, and construction. Quality support for future NASA missions requires continued pursuit of prudent, but creative, solutions to these challenges.

NASA's mission focus is on five enterprises: Space Science, Earth Science, Biological and Physical Research, Human Exploration and Development of Space, and Aerospace Technology. Each NASA installation has a unique mission and is a Center of Excellence supporting one or more of these enterprises. Centers of Excellence support program requirements and strengthen the long-term capabilities of the Agency and the Nation. NASA Centers, their missions, and their Centers of Excellence, are depicted in Figure 1. Facilities managers maintain operational facilities while "reducing the financial drag" on aeronautics and space programs. To provide quality, affordable services, NASA facilities managers use many tools, including: performance-based contracting, Reliability-Centered Maintenance (RCM), energy saving performance contracts, public-private partnerships, interagency agreements, and sophisticated facilities management techniques. NASA's existing operational facilities are the result of sustained superior performance of facilities engineering staffs.

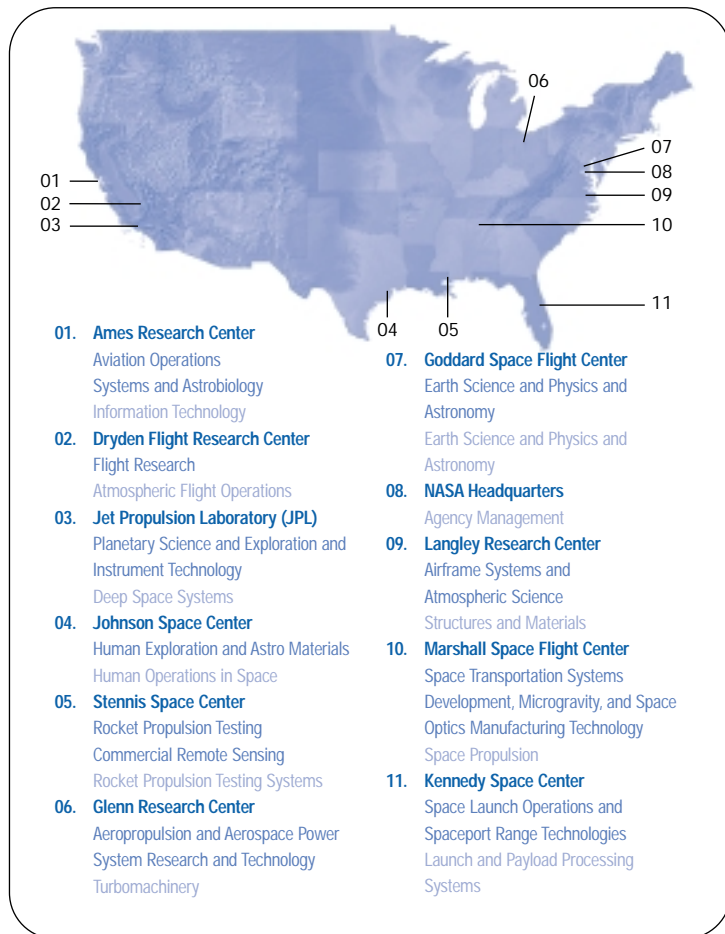


Figure 1. NASA Centers, Missions, and Centers of Excellence

# history

## History

October 1, 1958, the official start of the National Aeronautics and Space Administration (NASA), was the beginning of a rich history of unique scientific and technological achievements in human space flight, aeronautics, space science, and space applications. Formed as a result of the *Sputnik* crisis of confidence, NASA inherited the earlier National Advisory Committee for Aeronautics (NACA) and other government organizations. Immediately upon formulation, NASA began working on options for human space flight. NASA's first high profile program was Project Mercury, an effort to learn if humans could survive in space. Project Gemini built upon Mercury's successes and employed spacecraft built for two astronauts. NASA's human space flight efforts then extended to the Moon with Project Apollo, culminating in 1969 when the Apollo 11 mission first put humans on the lunar surface. NASA's current human space flight efforts include the Space Shuttle program, which continues today to help

*"NASA is deeply committed  
to spreading the  
unique knowledge  
that flows from  
its aeronautics and  
space research..."*

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Daniel S. Goldin  
NASA Administrator  
Strategic Plan 2000

## NASA Mission

- To advance and communicate scientific knowledge and understanding of Earth, the solar system, and the universe
- To advance human exploration, use, and development of space
- To research, develop, verify, and transfer advanced aeronautics and space technologies

build the International Space Station. Centers were created around the country to support Project Mercury, Project Gemini, and Project Apollo. These Centers are still in use today supporting NASA's emerging new missions. The following is a brief description of each Center, its Mission, its Centers of Excellence, and its unique facilities engineering processes.



## Vision

NASA's bold vision for the 21st century includes partnering with local communities, academia, private industry, non-profit organizations, and other government agencies. This vision includes partnerships to improve facilities management. Each NASA Center is updating its Master Plan, including requirements, capital improvement plans, and facilities goals. Successful Master Plans are leveraging partnerships to modernize facilities while providing more efficient support to future



missions. Partnerships bring parties with shared interests together, allowing NASA to leverage non-Federal funding in the planning and construction of facilities. These partnerships continue during the operational phase to improve mission support. One of the more aggressive partnerships being fostered is the NASA Research Park at Ames Research Center. NASA's partners include local communities, academia, private industry, and non-profit organizations.

In the heart of Silicon Valley, NASA is developing a world-class R&D campus: the NASA Research Park. This 200-acre area will be located at Moffett Field, a federal property that NASA acquired from the Navy in 1994. This research park will be open to the public. Here the space agency and its new partners will pursue aeronautics research for the next century.

# vision

# centers

## Centers

Ames Research Center (ARC) is NASA's Center of Excellence for Information Technology. Founded in 1939, ARC develops leading-edge aerospace technologies and services; conducts research in the Earth, life, and space sciences; and develops information systems and technologies enabling all NASA missions. Ames scientists conduct basic research, participate in flight missions, and participate with the national science community in astrobiology

research. Among ARC's 6.8 million square feet of facilities are the historic hangars used to house blimps during World War II, and the National Full-Scale Aerodynamics Wind Tunnel Complex containing the largest wind tunnel west of the Mississippi River. The current facilities replacement value is \$2.6 billion.



*DFRC: Space Shuttle Mate/Demate Facility*

Dryden Flight Research Center (DFRC) is NASA's Center of Excellence for Atmospheric Flight Operations. DFRC staff perform research and development to verify and transfer advanced aeronautics, space, and related technologies. Strategically situated in Southern California's Mojave Desert, DFRC has been home of the historic X-plane testing since 1946. Access to Edwards Air Force Base (AFB) supersonic test ranges and an impressive array of flight monitoring equipment combine to provide one-of-a-kind flight-testing capability. Edwards AFB provides excellent infrastructure support, including utilities distribution, roads and grounds maintenance, airfield services, and real estate management services. DFRC's facilities have a current replacement value of \$0.3 billion.



*GRC: Test Stand*

Glenn Research Center (GRC) is NASA's Center of Excellence in Turbomachinery, and has been an international leader in aeropropulsion research since 1941. GRC develops technologies for fans, pumps, compressors, turbines, and air-breathing engines to propel aircraft and spacecraft in the new century. In addition, GRC has a mission in aerospace power research and technology and supports efforts in icing research, aviation safety,

the International Space Station, microgravity research, and advanced space transportation. These research missions are supported by unique ground test facilities such as two recirculating, supersonic wind tunnels with combustion testing capability; the world's largest icing wind tunnel; thermal vacuum facilities; and free-fall drop facilities at the Cleveland site. Plumbrook Station facilities include the largest vacuum facility in the world, and a hypersonic tunnel used to test space propulsion systems. GRC has 3.4 million square feet of facilities on 7,100 acres with a total current replacement value of \$2.4 billion.

Goddard Space Flight Center (GSFC) is NASA's Center of Excellence for Earth Science and Physics and Astronomy. Established in 1959, Goddard has diverse responsibilities ranging from research in Earth science and astrophysics to satellite tracking and control. GSFC plays a major role in expanding our knowledge of Earth and its environment, the solar system, and the universe through observations from space. GSFC has many world class facilities including the High Capacity Centrifuge facility, the Hubble Space Telescope Control Center, the Space Environment Simulator, and the newly constructed Earth Observing System Data Information System facility. GSFC is responsible for the Sub-orbital and Small Orbital Sounding Rocket and Scientific Balloon Programs conducted at Wallops Flight Facility (WFF) on Virginia's Eastern Shore. WFF has partnerships with the U.S. Navy, U.S. Coast Guard, U.S. Department of Commerce's National Oceanographic and Atmospheric Administration, and the Spaceport Virginia organization for operating and maintaining launch, tracking, and airport services. The infrastructure at GSFC and WFF includes 4.5 million square feet with a current replacement value of \$1.5 billion.

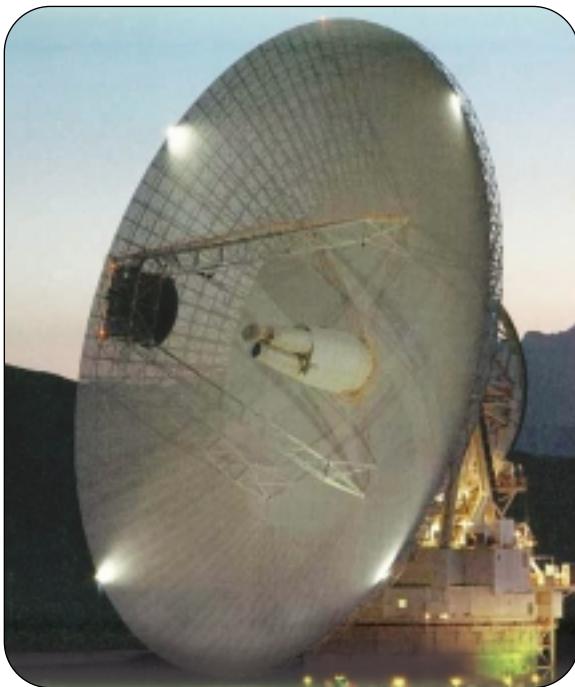


*WFF: Sounding Rocket*

Stennis Space Center (SSC) is NASA's lead Center for Rocket Propulsion Testing and for Commercial Remote Sensing within the Earth Sciences Enterprise. SSC has the largest rocket propulsion-testing complex in the Nation. In addition, SSC is home to the RS-68 Engine Assembly Facility, which produces the latest large, liquid-fueled engine developed at Rocketdyne Propulsion & Power, a division of The Boeing Company. The E-3 facility tests new hybrid and hydrogen peroxide rocket propulsion systems, including a small-scale horizontally positioned hybrid rocket motor. This past year, SSC expanded its use of



*SSC: Rocket Propulsion Test*



*JPL: Goldstone Deep Space Network*

Reliability-Centered Maintenance (RCM) to include test equipment within the Rocket Engine Test complex. SSC's 1.5 million square feet of facilities have a current replacement value of \$1.5 billion.

Managed by the California Institute of Technology, the Jet Propulsion Laboratory (JPL), established in 1944, is NASA's principal Center for the Robotic Exploration of the Solar System. With over 175 acres in the San Gabriel foothills, JPL has 155 facilities with 2.1 million square feet of facilities and a current replacement value of \$0.6 billion. JPL is NASA's Center of Excellence for Deep Space Systems; its spacecraft have visited all known planets except Pluto. The global Deep Space Network communicates with spacecraft and conducts scientific investigations from complexes in: Goldstone in the Mojave Desert; Madrid, Spain; and Canberra, Australia.

Johnson Space Center (JSC) is NASA's Center of Excellence for Human Operations in Space. Established in 1961, JSC manages the Space Shuttle and International Space Station programs.



*JSC: Apollo 11 Celebration at Mission Control, Houston*

Located in Houston, Texas, JSC is home to the Mission Control Center for every piloted U.S. space mission. The Center played a critical role in the Gemini, Apollo, and Skylab projects, and controls today's Space Shuttle and International Space Station flights. In 1996, JSC was awarded NASA's first fixed-price, performance-based Center Operations Support Services (COSS) contract. JSC is currently preparing the solicitation for the first of NASA's second generation COSS contracts. JSC manages the White Sands Test Facility in New Mexico, home for testing and research of Space Shuttle propulsion components, and the White Sands Space Harbor, which provides approach and landing training for Space Shuttle astronauts. JSC's 5.6 million square feet of facilities have a current replacement value of \$1.6 billion.

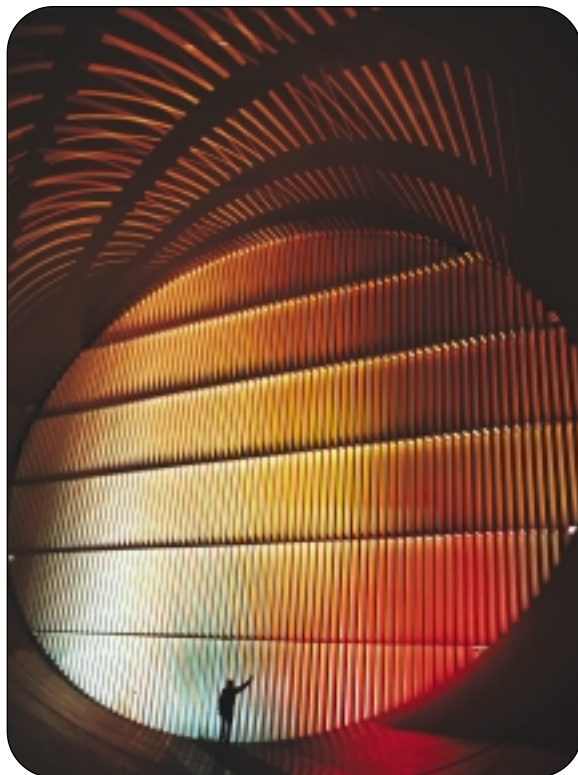
John F. Kennedy Space Center (KSC) was created in the early 1960's as the launch site for

Apollo missions to the Moon. Today, KSC is the Center of Excellence for Launch and Payload Processing Systems, including the Space Shuttle and International Space Station. KSC supports the Space Launch Operations and Spaceport Range Technologies program. KSC is the largest NASA Center, with more than 6.7 million square feet of facilities on 83,000 acres. Operations and maintenance of the infrastructure is accomplished under three separate performance-based contracts, including one Joint Base Operations Support Contract (JBOSC) with Cape Canaveral Air Force Base. Recently, KSC completed construction of a 10-megawatt power plant in cooperation with Florida Power and Light. The project, paid for with third-party funds, provides an alternate power source during peak demand periods, reducing KSC's utility bill. The current facilities replacement value is \$3.4 billion.



*KSC: Space Shuttle Launch*

Langley Research Center (LaRC) is NASA's Center of Excellence for Structures and Materials. Established in 1917 as the Nation's first aeronautical research laboratory, Langley is responsible for some of the most important aeronautical advances of the 20th century. LaRC's primary mission assignments are Airframe Systems and Atmospheric Science. LaRC manages high-payoff Agency programs in aviation safety, airframe systems, high-speed research, and advanced subsonics. LaRC is NASA's focal point for wind tunnels and test facilities. The National Transonic Dynamics Tunnel, the 8-Foot High Temperature Tunnel, and the Supersonic Low-Disturbance Tunnel are national assets. LaRC has many unique facilities including the Flight Simulation Facility, the Impact Dynamics Research Facility, and the Aircraft Landing Dynamics Facility. LaRC facilities utilize multiple engineering contracts to address all institutional and utility projects as well as overflow of unique/adaptive research systems projects. This approach balances in-house engineering



*LaRC: Wind Tunnel*



*MSFC: Space Shuttle Main Engine (SSME) Test Firing*



*MAF: Aerial view*

support for Construction of Facilities (CoF) management, planning, and implementation as well as strategic support for the research community. LaRC's 2.8 million square feet of facilities have a current replacement value of \$2.1 billion.

Marshall Space Flight Center (MSFC) is NASA's Center of Excellence for Rocket Propulsion and Testing Systems. Located in Huntsville, Alabama, Marshall is NASA's principal Center for space transportation systems and development. The center is NASA's leader in microgravity research and space product development programs. The recently completed Space Optics Manufacturing Technology Center supports development of advanced, ultra-lightweight optics materials, fabrication technology, precise measurement standards, and state-of-the-art testing facilities. The Global Hydrology and Climate Center is the premier climatology research facility in the southeastern United States. The Space Shuttle's external tanks are manufactured at the Michoud Assembly Facility (MAF) near New Orleans, Louisiana. Mishoud is one of the world's largest factories, covering 43 acres under one roof. MSFC's 4.4 million square feet of facilities have a current replacement value of \$2.1 billion.

# functions

## Facilities Engineering Functions

### Planning and Real Property

Center directors and Enterprise managers drive NASA facilities requirements. Facilities managers work closely with the operational managers to anticipate future facilities and real property requirements through comprehensive master planning and project specific planning. Master planning balances current and future facilities and real property requirements against existing assets, identifies excesses and shortfalls, and develops strategies to meet competing demands. A Center master plan documents construction or renovation project requirements. Planners consider existing facilities and real estate, and other constraints in evaluating reasonable project alternatives. NASA's automated real property and facilities utilization database simplifies the planning process and enables reporting requirements and management decisions. Centers use creative public/private ventures to meet emerging requirements, benefiting NASA and the private sector. Real estate managers continually review property utilization metrics to increase efficiency and determine if property can be more effectively used or released for public or private use.

The current goals of the Planning and Real Estate Management Team are:

- Perform integrated Master Planning and utilization studies.
- Perform assessments and analyses across the Agency.
- Maintain and improve data systems and architecture.

### Design and Construction

Newly constructed Federal facilities represent significant investments of increasingly scarce resources. Federal facilities normally are not removed from use for many decades. Business motives dictate renovation or demolition of private sector facilities; this practice is not applicable for Federal facilities. As a result, project managers must plan, design, and construct facilities to last much longer than their private-sector counterparts. A variety of laws and regulations require project managers to meet social goals while producing efficient, effective, and fiscally prudent facilities. NASA project managers use industry best practices, including partnering, value engineering, sustainable design, and building commissioning to maximize return on

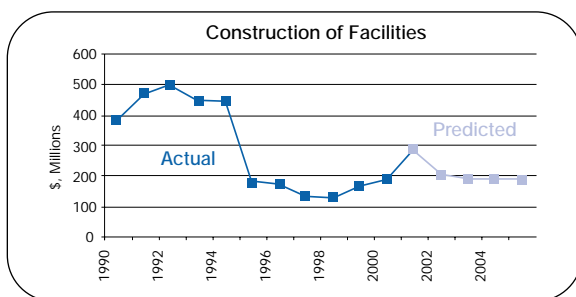


Figure 2. Construction of Facilities Projection

investments and produce facilities at the lowest possible life cycle costs. The Construction of Facilities (CoF) program funds new construction and significant renovation projects at NASA Centers. Figure 2 shows CoF funding projections for 1990 to 2005. Recent CoF program funding has been near historic low levels. Given this reduced funding, it is important to select only the most critical projects, and to construct those projects efficiently.

The current goals of the Design and Construction Team included the following:

- Sustain significant improvements, 5 percent annually, in the Agency's buying power within the CoF program by continuing to advance best practices and lessons learned throughout the Agency.
- Identify alternatives to new construction to meet emerging Enterprise facilities needs.

## Facilities Maintenance

Facilities maintenance ensures facilities are available and reliable. Using the Reliability-Centered Maintenance (RCM) approach, facilities engineers achieve system availability requirements using the most effective mix of preventive, predictive, proactive, and reactive maintenance practices. Maintaining the buildings, utility systems, and infrastructure that support user requirements and comply with current regulations is significant given the critical nature of NASA Center missions. Facility reliability and availability are crucial to completing space flight and research missions every day.

The current goals of the Facilities Maintenance Team are to:

- Encourage and facilitate maintenance innovation.
- Research, educate, manage, and share innovative and technological Operations and Maintenance (O&M) activities and approaches at each Center.
- Research, develop, and coordinate the use of standardized facilities O&M tools.
- Create and maintain a culture of open communication. Foster trust and the free exchange of ideas for improvement.

## Resources

NASA resource managers support all facilities engineering functions. Resource managers analyze and optimize financial management, budget development, and funds expenditures. They interface with facility users and other external stakeholders, including the Office of Management and Budget (OMB) and Congressional staff members.

The current goals of the Resource and Budget Team include:

- Providing resources required for facilities to achieve program goals.
- Ensuring resources are programmed and accounted for to maximize buying power and to support Agency missions.
- Providing financial management control to ensure proper use of Agency resources and to maintain budget integrity.

# code jx

## Headquarters Facilities Engineering Division, Code JX

Code JX is one of eight divisions within the Headquarters Office of Management Systems (Code J). Further information on the eight divisions is available at [www.hq.nasa.gov/office/codej/codej.html](http://www.hq.nasa.gov/office/codej/codej.html). The JX team provides leadership, establishes policy, and assists NASA's Enterprises/Institutional Program Offices (IPOs) and Centers regarding facilities engineering programs and initiatives. Figure 3 lists many of the policies, guidelines, and training tools Code JX provides Center facilities managers to improve their facilities management practices. The Division reaches out to Center facilities managers and other non-NASA organizations to find opportunities for optimizing facilities management methods. The NASA Administrator relies on JX to support essential facilities programs with OMB, Congress, and the Administration. The Headquarters facilities managers interact with their counterparts from other agencies in the interest of improving NASA's facilities programs and processes.

Center facilities engineering directors are responsible for the daily operation and management of facilities programs. Code JX provides support when requested to resolve significant facilities challenges. To deal with reduced staffing, NASA's Enterprise/IPO managers increasingly rely on Headquarters facilities engineering staff to develop solutions to their facilities management challenges. Code JX provides "smart buyer" services, advising them on a wide variety of planning, design, construction, and facilities maintenance issues. Through its RCM initiatives, Code JX has helped Centers maintain facility reliability and availability while undergoing significant maintenance budget reductions. Headquarters-funded training and contract support has helped Centers shift to performance-based Center operations support services contracts, thus reducing costs while maintaining desired levels of service.

### Tools Provided by JX

- Delegation of Facilities Projects Authority
- Facility Project Implementation Handbook
- Policy for Real Property Management
- Real Estate Management Program Implementation Manual
- Procedures and Guidelines on Facilities Maintenance Management
- CoF Best Practices Course
- RCM Guidelines and Training

OMB reviews and approves NASA budget requests. The NASA Comptroller coordinates all planning, programming, and budgeting submissions with OMB. Code JX provides the Comptroller technical and financial support, and ensures facilities management and CoF budgets are credible and defensible.

*Figure 3. Sampling of Center Facilities Tools*

NASA facilities managers are aware of and sensitive to environmental and energy program concerns. Code JX and the Environmental Management Division (Code JE) at NASA Headquarters coordinate matters of mutual concern. Teaming between JX and JE has enabled significant advances in shared energy savings, sustainable design of facilities, and environmental compliance.

Code JE's annual report to OMB highlighted the following environmental and energy program accomplishments, which were fully supported by the facilities engineering division:

- Revised NASA Policy Guide 8570.X, Environmental Program Management.
- Created Energy Efficiency and Water Conservation training course.
- Established a Headquarters Energy Efficiency Board.
- Held the NASA 2000 Environmental Conference.
- Conducted energy spot checks at several NASA Centers.
- Enhanced the NASA Environmental Tracking System (NETS).

NASA's mission success starts with safety; Code Q is NASA's Office of Safety and Mission Assurance (S&MA). A commitment to safety permeates everything NASA does. NASA is committed to protecting the safety of the public, astronauts and pilots, the NASA workforce, and NASA's high-value equipment and property. In June 2000, the NASA technical community embedded the principles of risk management into the NASA Federal Acquisition Regulation (FAR) Supplement, which governs how projects and programs are planned and managed. Risk-Based Acquisition Management seeks to integrate risk principles throughout the entire acquisition process. The intent of these changes is to inject the principles and practices of risk management into the acquisition cycle earlier than in the past. This represents a new opportunity for S&MA and procurement communities to work together and make a difference in the safety and success of future NASA programs and projects.

## Metrics

End-of-year Fiscal Year 2000 CoF program obligations for construction exceeded 80 percent. This was the second year in a row that obligations exceeded 80 percent, and reflects increased emphasis on early design authority and construction contract awards at the earliest possible time in the budget year. NASA construction program metrics include design completions, construction time growth, construction cost growth, lost time incident/accident rates, and contract awards. Future staffing constraints may make it extremely difficult to sustain the high level of program implementation.

In Fiscal Year 2000, NASA's Backlog of Maintenance and Repair (BMAR) was \$959 million, as noted in Figure 4. BMAR is the deferred, unfunded cost of identified repairs.

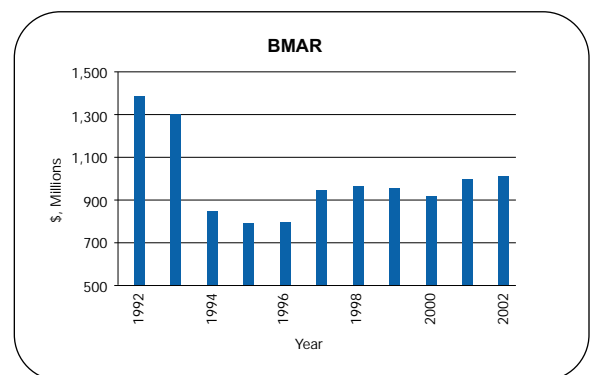


Figure 4. Backlog of Maintenance and Repair

# accomplishments

## Accomplishments

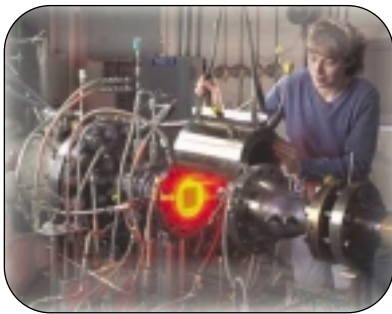
### Planning and Real Property

The NASA Research Park at Ames Research Center is a remarkable example of public-private cooperation and innovation in real property management. Under the plan, a private developer will renovate several historic properties at Ames' Shenandoah Plaza, preserving their historic nature while revitalizing the facilities. These restored structures will be leased to firms engaging in technology research related to NASA missions.

Under a partnership with the State of Florida, Kennedy Space Center will design and construct a new Space Experiment Research Processing Laboratory (SERPL). The SERPL facility will support biological research programs destined for the International Space Station. This \$30 million complex will be constructed with State funds and leased to NASA contractors supporting this important research program.

In 2000, NASA completed its update of the real property database. The database now includes current and accurate records of all owned and leased real property. The database provides input for many Center and Agency reports, and allows managers to monitor and improve asset utilization.

### Design and Construction



*GRC: Program Test*

NASA Facilities Design and Construction staffs have improved productivity while undergoing personnel reductions. NASA is implementing new best practices to further productivity gains and improve the requirements development and construction process. An Engineering and Construction Innovations Committee (ECIC), consisting of senior Headquarters and Center experts, was formed in late 1998 to foster best practices implementation, improve communications among Design/Construction personnel across NASA, and foster an environment of continuous improvement. ECIC developed a NASA Project Definition Rating Index (PDRI) guide to significantly improve the early planning process, fostered the reinvention of the NASA CoF Management training course, facilitated the development of a new RCM Equipment Acceptance training course, and participated in a myriad of other important activities to improve NASA's Design and Construction process.

Recently completed CoF projects include the following:

- Modification of the Stratospheric Observatory for Infrared Astronomy (SOFIA) Ground Support Facility, ARC, \$7.1M
- Rehabilitation of High Voltage System, Phase 1, GRC, \$9.0M

- Construction of Emergency Services Building, JPL, \$4.6M
- Construction of In-Situ Instrument Services Laboratory, JPL, \$5.0M
- Replacement of Central Chilled Water Equipment, Building 24, JSC, \$5.1M
- Construction of Helium Gasification Facility, KSC, \$5.7M
- Construction of Safe Haven, KSC, \$5.7M
- Rehabilitation of 480 Volt Electrical Distribution System, MAF, \$9.1M
- Modifications to the Chilled Water System, MSFC, \$20.6M
- Construction of Addition to Administration Building, SSC, \$6.5M

## Facilities Maintenance

By using RCM practices, Centers have realized direct savings of more than \$25 million, and absorbed maintenance budget reductions over the last five years of almost \$275 million. As Figure 5 indicates, RCM has helped shift maintenance programs away from reactive or “breakdown” maintenance, to more scheduled and predictive maintenance practices. Improved maintenance practices enabled facilities

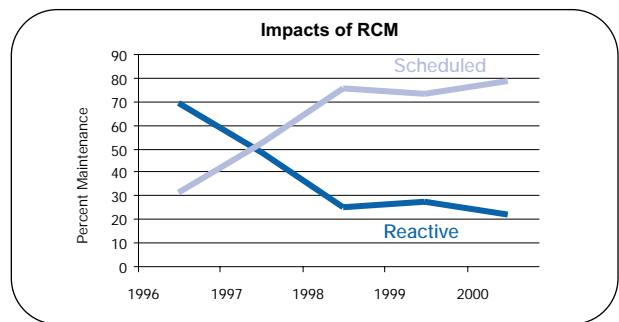


Figure 5. Reactive vs. Scheduled Maintenance



JSC: Aerial View

staff to meet system availability and reliability requirements while coping with budget reductions. Although the RCM program has been a tremendous success, it will not ensure future system reliability in the face of continued maintenance budget shortfalls.

Over the past five years, NASA facilities managers leveraged emerging technology to improve facilities management practices. All Centers invested in computerized maintenance management systems (CMMS),

which capture maintenance procedures, equipment history and reliability trends, and operations and maintenance costs. Most centers use the Maximo™ CMMS to monitor contractor performance and continually improve maintenance programs. CMMS forms the basis for all planned maintenance programs and records equipment maintenance. Palmtop CMMS interfaces are being considered for inclusion into the maintenance management function.

NASA has successfully outsourced facilities maintenance and operation functions at nearly all field installations. Most Centers are preparing to award their second-generation contracts, and are implementing lessons learned and best practices to improve Center support while controlling costs.

All Centers use Energy Management Control Systems (EMCS) to lower energy consumption and costs in high demand facilities. The EMCS systems provide real-time feedback when performance problems occur, allowing maintenance personnel to respond promptly without impacting Center missions. These systems also control heating, ventilation, and lighting in critical facilities, ensuring occupant comfort while minimizing utility consumption and costs. Centers are beginning to use Energy Savings Performance Contracts to install energy savings products and facility upgrades, further lowering the life cycle costs of owned assets.

## External Alliances

### Construction Industry Institute (CII)

NASA is a leader among Federal agencies in partnering with the private sector to leverage emerging technologies. As a member of the executive committee for the Construction Industry Institute (CII), NASA engineers participate in studies to advance the state-of-the-art in construction and facilities management. CII is a non-profit organization including corporations from many business sectors and internationally acclaimed construction and facilities management companies. CII aims to improve member construction and facilities maintenance buying power.

CII has 85 ongoing research projects. NASA is the co-chair of the "Design for Maintainability" project. "Maintainability" will improve project designs, resulting in less rework, smoother facility startups, and lower life-cycle costs. NASA will incorporate "maintainability" into a "best practices" course for Center engineers.

CII and NASA support the Fully Integrated and Automated Technology (FIATECH) Consortium. The National Institute of Standards and Technology (NIST) and CII formed this non-profit group to accelerate research and development of fully integrated and automated project processes. FIATECH will significantly improve facility design, construction, and maintenance operations, enabling real-time detection and correction of differences between design requirements and ongoing construction. FIATECH will also resolve an age-old problem of accurately capturing project "as-built drawings."

### National Institute of Standards and Technology (NIST)

NIST develops national standards for computer-automated design and drafting (CADD) and geographic information system (GIS) technology. NASA supports research to investigate CADD technology to "geo- spatially" manage the life of a facility. This research determines how facility condition data can be monitored and assimilated to display reliability and operability of a building.

### National Institute of Building Sciences (NIBS)

NASA is a member organization with the National Institute of Buildings Sciences (NIBS). The NIBS Total Building Commissioning Committee is developing national standards for a commissioning process to ensure that constructed facilities will operate as intended. The committee is working with standards organizations for each building trade to ensure the commissioning process gains national credibility.

The NIBS-designed Whole Building Design Guide (WBDG) (<http://www.wbdg.org/>) is a user-friendly Internet resource. The WBDG references current planning criteria, guide specifications, and energy and environmental project information. The WBDG encourages integrated thinking and a "whole building" performance perspective. Users can access information in three categories: Building Types, Design Criteria, and Products and Systems.

external alliances

# agency integration

## Federal Agency Integration

NASA is a key player in Federal agency integration. This sharing between Federal agencies goes much deeper than just sharing information. Several resources have been designed and implemented in this cross-agency integration. NASA strongly supports the Federal Facilities Council (FFC), which promotes cooperation between Federal agencies and with the private sector to design, construct, acquire, evaluate, and operate Federal facilities. The NASA Facilities Engineering Director is the vice chairman of the FFC, providing leadership and direction. Several NASA engineers are members of FFC committees, including the Operations and Maintenance Committee, the Design and Construction Committee, and the Project and Acquisition Management Committee. NASA engineers have been contributors on several FFC studies, including the Financial Accounting Standards Advisory Board Study on deferred maintenance. This study is being used to develop a model to efficiently and reliably estimate facilities maintenance backlogs.

NASA and the Department of Defense (DoD) created the Major Facilities Alliances to shape the use and investment strategies for similar NASA/DoD facilities. The goal is to share critical but underused facilities, thus avoiding construction, operation, and maintenance costs to both agencies.

The National Aeronautical Test Alliance (NATA) optimizes the strategic management of Government-owned Wind Tunnel and Air Breathing Propulsion Test Facilities. Under the leadership of NATA, the national Wind Tunnel Alliance is assessing the testing capability and capacity required for air-breathing propulsion test facilities. The National Rocket Propulsion Test Alliance schedules multi-agency testing in these highly sophisticated facilities and is developing a joint investment strategy to modernize those assets. The Arc Heated Test Facilities Alliance has little or no overlap between Department of Defense (DOD) and NASA facilities. Members exchange test equipment as needed in order to support customers. The Hypervelocity Ballistic/Impact Range Testing Alliance coordinates complementary use of facilities and has good communication and exchange of technical information between NASA and DOD. In summary, Facilities Alliances has proven their value and increased expectations that they will maximize use of critical assets and save money.

Another example of cross-agency integration of resources and capabilities is the NASA-Air Force Joint-Base Operations and Support Contract (J-BOSC), which consolidated 18 smaller contracts, providing base support services at the KSC, Patrick AFB, and Cape Canaveral Air Station. The services include infrastructure operations, engineering and maintenance, security, logistics, and medical, environmental, and administrative services. J-BOSC reduces costs through less dependence on government furnished property, while increasing flexibility, enhancing capabilities, and improving business practices and system reliability. A similar joint contract will soon be awarded between Wallops Flight Facility and the Navy.

## Challenges and Opportunities

NASA's facilities are aging. The engineering workforce is aging. Funding for facilities maintenance and repair is flat or declining. Adequate support of future NASA missions requires a continued pursuit of both prudent and creative solutions to facilities challenges. NASA facilities managers must face these 21st century challenges head on, and use them as a stimulus to create new opportunities. Some of the immediate challenges and opportunities are described below.

**Challenge #1:** NASA's mission is dynamic. From developing a lower cost, reusable launch vehicle to newer, more powerful Shuttle engines, mission changes directly impact facilities and infrastructure requirements. Future demands to modify aging facilities or to construct facilities for new mission requirements will increase. These changes will occur in the midst of constrained facilities construction and maintenance budgets.

**Opportunity #1:** The current fiscal environment is forcing improvements in return on investment through the diligent use of emerging best practices. NASA recently completed a study recommending the implementation of three emerging practices in future facilities projects. The study provides a framework for integrating sustainable design, design for maintainability, and building commissioning into an overarching "sustainability" practice. Sustainability principles are applied through all phases of facility acquisition, and create efficient and productive facilities while minimizing life-cycle operation and maintenance costs.

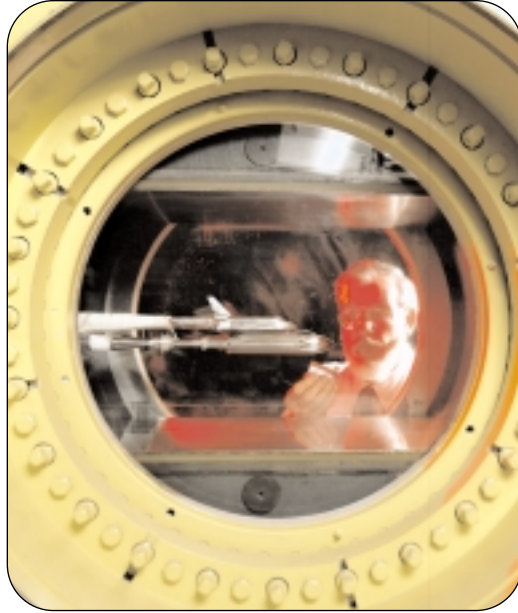
The essential elements of sustainability include:

- Energy efficiency and water conservation.
- Site selection to minimize environmental and transportation impacts.
- Use of sustainable materials (i.e., reused, recycled, recyclable, non-toxic, low-embodied energy content, renewable).
- Emphasis on durability and efficiency of materials and equipment.
- A healthy environment, including indoor air quality.
- Features in support of enhanced worker productivity.
- Design for personnel safety and security.
- Design for decommissioning and disposal.
- Enhanced building operating and maintenance characteristics.

# opportunities

NASA's application of building commissioning integrates reliability-centered building and equipment acceptance criteria into the traditional commissioning process. By using available predictive testing and inspection (PT&I) technologies, combined with thorough baseline, installation, and manufacturer documentation and traditional operational parameters, acceptance testing will identify latent defects, reduce premature failures, increase safety and reliability, and decrease life cycle costs.

Building Commissioning validates and documents building systems performance and conforms to the intended design criteria. Commissioning activities during planning, design, construction, and startup improve the cumulative building performance and lower total facility life-cycle costs.



*MSFC: Shuttle Model in Wind Tunnel*

Projects to revitalize aging but essential facilities dominate the current five-year CoF program. A number of important new construction projects will provide state-of-the-art facilities to support 21st Century missions. Notable projects include:

- 34-Meter, Multi-frequency Beam Waveguide Antennas, JPL/DSN
- Rocket Based Combined Cycle (RBCC) Test Facility, MSFC
- Space Experiment Research Processing Laboratory, KSC
- Booster Applications Facility, Brookhaven National Laboratory, Department of Energy.
- Flight Projects Center, JPL

**Challenge #2:** The majority of NASA's facilities were built during the 1960's to support the Apollo program. Since then, a smaller number of large, unique, and world-class facilities have been built. Many facilities require intensive amounts of maintenance and repair to maintain a safe, professional working environment. NASA's challenge is to maintain safe and reliable facilities while minimizing facilities operations and maintenance costs.

**Opportunity #2:** The future challenge will be to extend RCM to all facilities operations and maintenance programs. Opportunities include encouraging new or existing O&M contractors to advance their maintenance practices and to lower or maintain costs despite the aging infrastructure and increasing maintenance demands.

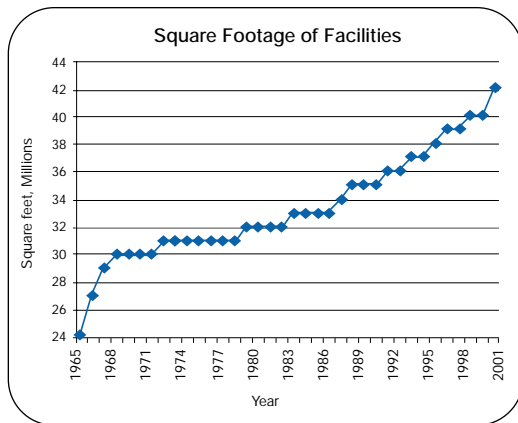


Figure 6. Square Footage of Facilities

is increasing over time. Figure 6, Square Footage of Facilities, shows that NASA infrastructure continues to increase over time. NASA is applying RCM principles to enable Centers to improve facility reliability in its aging infrastructure without commensurate increases in operations and maintenance budgets.

NASA has developed reliability-centered testing and acceptance guidelines and training materials for use by project designers and project managers during the acceptance phase of the construction project. All significant CoF or Enterprise-funded projects will benefit by ensuring facilities systems perform to minimum standards before NASA accepts facilities as complete. Starting the O&M phase with properly functioning equipment will lower life-cycle costs and improve safety, availability, and reliability of required systems.



LaRC: Langley's First Wind Tunnel

NASA, recognizing RCM's substantial and documented strengths and paybacks, supplements its commissioning program with specific reliability-centered criteria that must be satisfied prior to NASA's acceptance of the building, system, or equipment from the contractor. It recognizes that substantial benefits can be gained during acceptance and as part of the contractor's quality control function. By using available PT&I technologies, combined with thorough baseline and installation/manufacture documentation and traditional operational parameters, acceptance testing will reduce premature failures, increase safety and reliability, and decrease life cycle costs.

**Challenge #3:** NASA's workforce, like the infrastructure, is aging. Facilities engineering and maintenance personnel were hired to support the increases in the infrastructure during the programs in past years (Apollo, Space Shuttle, etc.). The corporate knowledge and experience of these veteran facilities managers will be difficult to replace as they leave Federal service in the coming years. Restrictions on hiring new personnel have compounded this facilities knowledge void. An inability to fill vacancies has left significant holes in capability or experience at many Centers. Retaining the inherent capability to remain a "smart buyer" of facilities and services is a challenge NASA must face head on.

**Opportunity #3:** During the next decade NASA must develop innovative ways to attract and retain junior and mid-level engineers to replace its veteran workforce. The Agency needs to publicize the opportunity it affords for forward-thinking engineers to work on unique, one-of-a-kind Federal facilities using industry accepted best engineering practices. The Agency must also keep pace with changing demands for amenities in the workplace. As investments are made to revitalize aging infrastructure, workplace quality issues must be properly addressed.

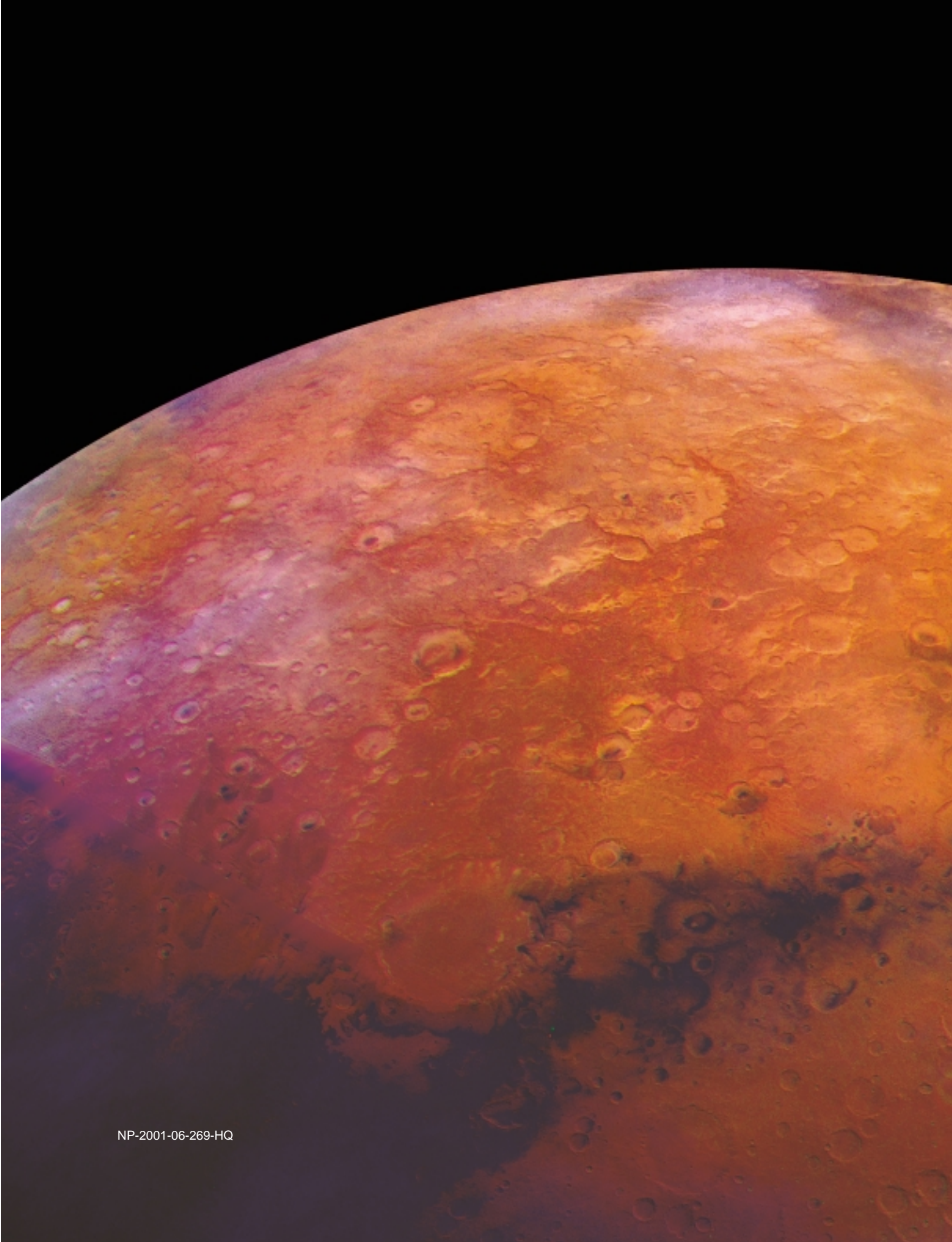
**Challenge #4:** NASA's backlog of maintenance and repair (BMAR) is approaching \$1 billion (see Figure 4, page 13). NASA must articulate the impacts of the increasing BMAR on facility reliability, availability, and the attendant risk to mission support. Without a credible analysis of the existing BMAR and its impacts, funding above current levels for maintenance and repair projects is unlikely. The effort and cost of determining an accurate BMAR is hampering the identification of critical maintenance shortfalls.

**Opportunity #4:** NASA Engineers, in cooperation with the Federal Facilities Council, are proposing a parametric estimating method to generate a more credible BMAR estimate without investing millions of dollars necessary for a wall-to-wall condition survey of all NASA facilities. In 2001, Headquarters will fund the effort to produce the estimating method and complete the assessment at each NASA Center. These parametric estimates should produce auditable BMAR reports, and will support prudent funding decisions for facilities improvements.

# strength

## Building on Strength

Continuing to meet the challenges of 21st-century facilities engineering and real property management requires innovation and diligence from proactive organizations, both large and small. The integration of modern technology, high-payoff research, and flexibility is the key to effective, low-cost support to NASA missions. NASA will continue to “extend the breakthroughs” in facilities engineering to assure NASA infrastructure supports our Nation’s goals in aeronautics and space, as well as enhance and enable the integration of engineering and facilities management excellence across Federal agencies. NASA will continue participating with others to develop information technology and investment decision processes that will pave the way in the years ahead.



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